Review Comments on EPA's Bristol Bay Watershed Assessment: Habitat Loss

Prepared for the Bristol Bay Native Corporation
by
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Introduction

At the request of the Bristol Bay Native Corporation, I reviewed portions of "An Assessment of Potential Mining Impacts on Salmon Ecosystems of Bristol Bay, Alaska (EPA 910-R-12-004a)," released for public comment by the United States Environmental Protection Agency, Seattle, WA in May 2012. My comments focus primarily on portions of this report (hereinafter abbreviated as BBWA, *i.e.*, Bristol Bay Watershed Assessment) that are related to potential discharges of dredged or fill material into regulated waters of the United States, including wetlands.

I find the BBWA to be straightforward, and its conclusions caveated carefully. It is my opinion that EPA likely underestimates all or most potential impacts, including direct and indirect impacts to wetland and aquatic areas.

The BBWA does not adequately address the difficulty (risks) of actually implementing a mine design that could practicably collect and treat mining wastewater to meet water quality standards at the point of discharge, particularly the quantities of water that will be necessary for a large-scale hardrock mine to operate in the "no failure" mode within the Bristol Bay watershed.[2] If such a design is not practicable for the short-term or long-term treatment of water, EPA's "no-failure" scenario is rendered meaningless. Accordingly, EPA should at least offer examples of large-scale hardrock mining operations that have successfully treated and discharged similar volumes of wastewater.

Similarly, the BBWA does not assess the challenges (risks) of offsetting habitat losses through compensatory mitigation. Whereas Appendix I discusses mitigation practices (including mine design, operation, and closure) and descriptions of mining industry standard practices, this 24-page report offers no specifics about the Bristol Bay watershed or mitigation practices therein. Appendix I cites the compensatory mitigation regulations under Section 404, but provides no assessment of what measures could actually be considered or implemented to offset losses in the Bristol Bay watershed, such as those associated with the Pebble project.

In this regard, EPA's BBWA indicates that even under its "no-failure" scenario there would be serious direct impacts to fish and wildlife habitats resulting from even the smallest (25-year)

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[2] However, the report does note that waste rock leachate would require a 2,900 - to 52,000-fold dilution to achieve water quality criteria, and that not collecting the leachate (2.8 billion gallons annually) could pollute all of Upper Talarik Creek and parts of Iliamna Lake (Chapter 8, page 8-7).

version of the Pebble project, but the BBWA falls short of assessing the likelihood that a mine could be constructed that could adequately offset habitat losses. As such, EPA seems to make a two-fold presumption that large-scale hardrock mining operations in the Bristol Bay watershed could be constructed to meet water quality standards (which seems doubtful) and could somehow offset direct and secondary losses of fish and wildlife habitats (which seems even more unlikely).

EPA should expand its BBWA to provide some assessment of the risks/probabilities that water quality standards could be met even under its "no fail" scenario, as well as the risks/probabilities that habitat losses could be offset through compensatory mitigation measures. EPA should provide examples if they exist, or explicitly acknowledge the lack of such examples. If such measures have never been achieved previously, it seems inappropriate for EPA to presume that it will be accomplished under a "no-failure" scenario.

Chapter Reviews

Chapter 3: Problem Formulation

Risks are appropriately tied to impacts to salmon and those human and animal populations that depend on these fishes. However, the actual ecological risks to wildlife go beyond their nutritional needs, and the direct loss of non-aquatic habitats, although perhaps small on a regional scale, are nevertheless substantial. Moreover, the risks associated with secondary impacts that mining and associated infrastructure would undoubtedly enable are specifically not considered in EPA's BBWA (Chapter 3, page 3-2, and page 3-4), and therefore are underestimates.

Fish species assessed are also limited to those that EPA considers more dependent upon rearing habitat than those that may spawn but not rear in those waters (Chapter 3, page 3-4). Similarly, some species considered important for subsistence and/or sport-fishing were not evaluated (considered representative) if their ecology was not well-known or if they were considered less sensitive than species selected for further analysis.

In its description of types of evidence and inference (Section 3.5), it seems inappropriate for EPA to identify the Fraser River as being an analogous watershed to BBWA even though the Fraser River watershed has hardrock mines and supports salmon resources (page 3-5), although EPA does note important differences. In fact, later in the BBWA Chapter 7, Box 7-1, page 7-2), EPA concludes that the Fraser River watershed is a "poor analog" because other development within the watershed "obscures any impacts of the mines at a watershed scale," and that most of the salmon runs therein "are listed as threatened or endangered."

Chapter 4: Mining Background and Scenario

In addition to summarizing information about mineral deposits in the Nushagak and Kvichak River watersheds, this chapter provides estimates of the surface area that would be covered by a 25-year mine at the Pebble Deposit, including the mine pit, waste rock disposal areas, and a tailings storage facility (TSF1) in an unnamed drainage that is tributary to the North Fork

Koktuli River. These hypothetical footprints are taken directly from Wardrop (2011)[3]. EPA estimates the mine pit to cover 1,358 acres, adjacent waste rock disposal areas to cover approximately 3,286 acres, and TSF1 to have a surface area of approximately 3,686 acres,[4] or a total footprint of 8,330 acres. Whereas it is safe to assume that all habitat (wetland, aquatic, and upland) would be destroyed within this footprint, these estimates appear to be substantially low.

EPA relies on engineering drawings of these mining features as shown in Wardrop (2011); Huffman-Broadway, Inc. made GIS measurements of these features that suggest the actual impacts may be substantially greater (approximately 9,400 acres), particularly if the strip of land between the mine pit and the surrounding waste rock disposal area is included, as well as a seepage cut-off area that abuts the waste rock disposal area. Inasmuch as EPA's estimated 25-year Pebble mine footprint appears to be more than 1,000 acres too low, its estimates of direct losses of habitat will also be correspondingly low.

Chapter 5: Risk Assessment: No Failure, Section 5.2: Habitat Modification

In estimating impacts of the Pebble 25-year mining project to wetland and aquatic areas, EPA relies upon National Wetlands Inventory (NWI) maps for the Bristol Bay watershed. These maps are produced from aerial photo interpretation of high altitude imagery, and are accompanied by little or no actual on-the-ground verification. EPA's reliance on the NWI maps likely leads to conclusions about potential impacts of large-scale hardrock mining operations on wetland and aquatic areas that are substantial underestimates. In fact, field studies by the Pebble Partnership (EBD Chapter 14: Wetlands) suggest that the reach and extent of wetland and aquatic areas that are shown in NWI maps within the proposed mine footprint may be 30% or more too low.

EBD Chapter 14 characterized roughly a third of its 29,430-acre "mine mapping" area as wetlands or aquatic habitats (9,826 acres). Using this ratio for illustrative purposes only, the roughly 9,400-acre combined footprint of the 25-year Pebble mine, waste rock disposal area, and tailing storage facility (that EPA estimates covers 8,330 acres) would result in the loss of over 3,100 acres[5] of wetland and aquatic habitats, or roughly 600 acres more than the 2,520 acres EPA estimates would be lost.[6]

These PLP estimates, though substantially greater than is estimated by the BBWA, may, nonetheless, be underestimates as well. PLP's wetland maps are derived from data taken at 865 sample sites that were extrapolated to characterize the entire 29,430-acre mine mapping area (approximately 1 sample site for every 34 acres). The EBD groundwater hydrology chapter (Chapter 8) includes drilling logs throughout the area of the Pebble Deposit, many of which include significant deposits of peat. In addition, the EBD geotechnical chapter (Chapter 6) describes areas where the mine, waste rock disposal areas, and tailing storage facility described

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[3] Wardrop. 2011. Preliminary assessment of the Pebble Project, southwest Alaska. Report to Northern Dynasty Minerals Ltd. by Wardrop, a Tetra Tech Company, Vancouver, British Columbia. February 15, 2011. 529 pages.

[4] EPA BBWA, Chapter 4, pages 4-15; *see also* Executive Summary, page ES-11.

[5] Given the landscape position of the Pebble deposit and likely TSF sites, as well as the underlying geology and extent of organic soils, this roughly 3,000-acre figure is also likely an underestimate.

[6] EPA BBWA, Chapter 5, pages 5-14.

by Wardrop (2011) as having soil and hydrology conditions (including thick layers of peat and descriptions of *"...numerous swamp/wetland areas in this area....The wet, boggy composition of this area is indicative of a groundwater discharge zone"*[7] that are likely indicators of wetland conditions.

Furthermore, 96% of the most common species that PLP lists in the vegetation survey of its "mine mapping area" (EBD Chapter 13) are known to occur in wetlands in Alaska with sufficient frequency to be listed on the Alaska list of wetland species. This prevalence alone suggests that wetlands may be more widespread than the 1/3 of the area delineated by the EBD, particularly in the low-lying drainage divide where the Pebble mine pit and waste rock disposal areas are proposed. However, inasmuch as the EBD did not provide any of its underlying wetlands field data and its mapping conventions, it is impossible to verify PLP's estimates.[8]

Chapter 7: Cumulative and Watershed-Scale Effects of Multiple Mines

One reason that EPA appears to identify the Fraser River watershed as an analog to the Bristol Bay watershed is that mining proponents claim that the Fraser River watershed is an example of the co-existence of mining and healthy fisheries (Chapter 7, Box 7-1, page 7-2). In fact, the Gibraltar mine in British Columbia has been cited specifically by the Pebble Partnership as an example of hardrock mining being compatible with large salmon runs. However, this mine is considerably smaller than that proposed by the Pebble Partnership at the Pebble Deposit, and although originally designed as a zero-discharge facility, the Gibraltar copper-molybdenum mine has been permitted since June 2009 to discharge effluent directly into the Fraser River.[9] EPA reports "episodes of low pH and frequently elevated dissolved copper" in waters at the Gibraltar mine (Chapter 7, Box 7-1, page 7-2).

It may be worth noting that the Gibraltar mine is operated by Taesko Mines Limited, which, like Northern Dynasty Minerals, is a subsidiary of Hunter Dickenson. Taesko's directorate includes managers of Northern Dynasty Minerals as well,[10] and the President and CEO of Northern Dynasty Minerals is President and CEO of its parent corporation, Hunter Dickenson.[11] In other words, the claims about the compatibility of mining and fisheries in the Fraser River appear to be coming from sources that not only operate that facility, but that are proposing a much larger mining operation in the Bristol Bay watershed. At best, what can be concluded is that the Pebble Partnership's claim that copper mining and maintenance of healthy salmon resources are compatible within a watershed is unsupported by the example it has provided.

In Section 7.4.1.1 (Habitat Eliminated Under the Mine Footprint), EPA appears to estimate the reach and extent of streams that would be eliminated or blocked by potential mining operations

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[7] EBD Chapter 6, pages 6-17.

[8] For further discussion of this and other aspects of the EBD, *see* Thomas G. Yocom, Review of Environmental Baseline Document Chapters Related to the Presence of Wetland and Aquatic Areas in the Vicinity of the Pebble Ore Deposit (2012), attached.

[9] *See* http://www.cohencommission.ca/en/pdf/PPR/PPR15 -Effluents.pdf.

[10] Northern Dynasty Minerals management (*see* http://www.northerndynastyminerals.com/ndm/Management_Directors.asp) includes directors that oversee Taesko Mines Limited, including its CEO (see: http://www.tasekomines.com/about -us/management/).

[11] *See* http://www.hdimining.com .

using State of Alaska data that is analogous to that shown on USGS quadrangles and/or the blue-line streams depicted therein. Such maps may grossly underestimate the existence and length of stream reaches given the means by which the maps were produced (high altitude imagery, often with little or no on-the-ground verification). For example, Figure 1 (attached) compares EPA's depiction of stream impacts (Chapter 7, Figure 7-2, page 7-11) in the North Fork Koktuli River drainage (TSF1) with the depiction of the same drainage as shown in Northern Dynasty Mines' 2006 water rights applications.

EPA estimates that approximately 9.2 miles of stream would be eliminated by TSF1. Simple inspection of Northern Dynasty Mine's depiction suggests that EPA's estimate is likely to be at least 50% low.

EPA's assessment of the direct habitat losses associated with TSF1 also appears to be low. EPA's estimate of the area of the TSF1 appears to measure from the top of the tailings dams rather than the outer perimeter of the toe of these dams, and may underestimate the footprint of TSF1 by more than 300 acres (Figure 2). And, EPA's estimates do not include a number of additional measurable impacts to wetland and aquatic areas that would result from a number of detention dams and sedimentation reservoirs that are depicted in the Wardrop report (2011), as well as direct losses resulting from construction and operation of the power plant, mill site, roads, support buildings, and associated infrastructure.

EPA does not provide a frame of reference for such magnitudes of losses of wetland and aquatic habitats, even for the underestimates that EPA presents. If possible, EPA should augment its risk assessment with examples of any hardrock mines in any watersheds in the United States whose impacts to wetland and aquatic habitats have been similar or greater, as well as examples where such impacts have been successfully offset with compensatory mitigation measures.

Finally, EPA assumes in its cumulative impacts analysis that other potential mines at the Sill and 38 Zone prospects would use the mill and TSFs built for the Pebble mine. EPA should also consider the potential additional cumulative impacts if that joint usage does not occur. Similarly, EPA assumes that the transportation corridor and perhaps some of the other associated facilities and power might also be used by other mining operations as part of a "mining district." These assumptions are conservative with regard to potential cumulative direct impacts, and would underestimate cumulative impacts of multiple mines if the assumptions prove not to be valid.

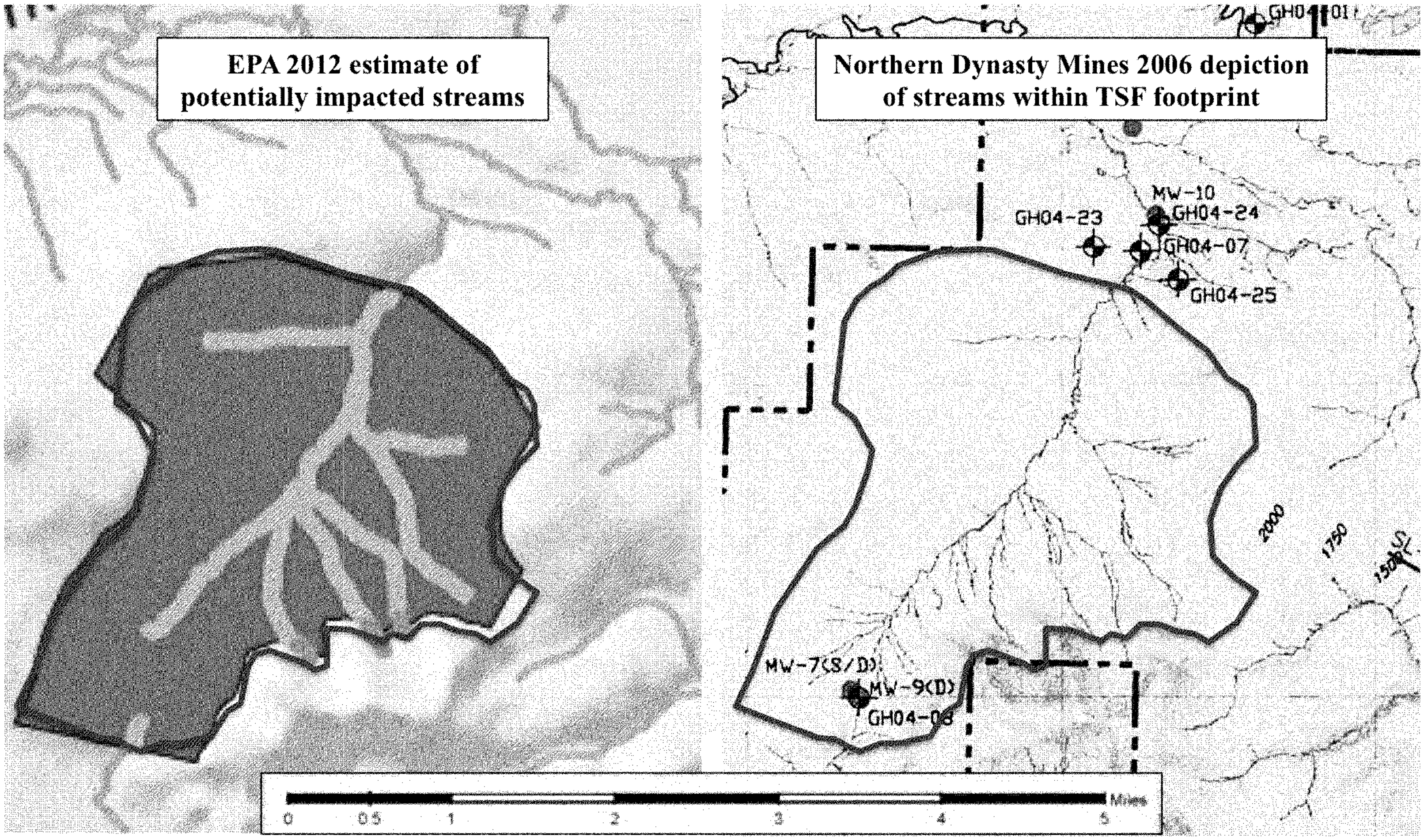

Figure 1: The reach and extent of streams impacted by a potential tailings storage facility (TSF) proposed for the minimum 25-year Pebble Mine Project (Wardrop 2011) as depicted in EPA's Bristol Bay Watershed Assessment (Figure 7-2) and as shown within the same drainage in a 2006 Northern Dynasty Mines water rights application. An outline of this TSF taken from Wardrop (2011) is shown in red.

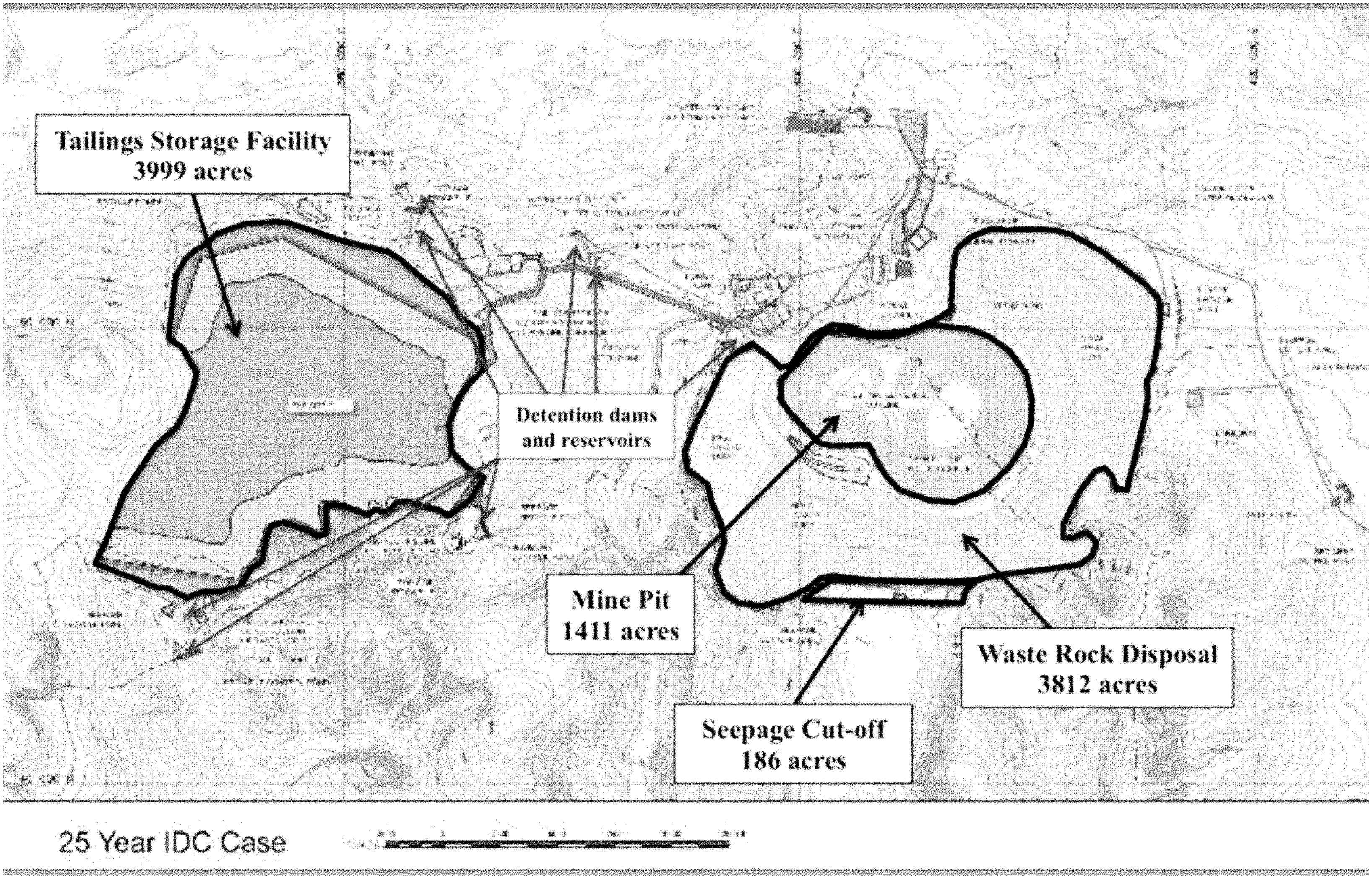

Figure 2. Approximate acreages of project features for the 25-year Pebble Project. Underlying figure from Wardrop (2011). Additional areas of impacts to wetland or aquatic areas include sediment control dams and reservoirs, some of which are shown on the underlying figure (highlighted with red arrows), but acreages were not estimated.

Attachment

Review of Environmental Baseline Document Chapters Related to the Presence of Wetland and Aquatic Areas in the Vicinity of the Pebble Ore Deposit

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June 5, 2012

Executive Summary

The Pebble Limited Partnership (PLP) has released its environmental baseline document (EBD) concluding that approximately 9,826 acres of wetland and aquatic habitats exist within its 29,430-acre mine mapping area. Its wetland maps show that a significant, but un-quantified portion of these habitats exist over and adjacent to the Pebble ore deposit, as well as within an area that PLP has previously proposed as a tailings storage facility (Wardrop 2011). Taken at face value, the EBD chapters suggest that very large areas of wetland and aquatic habitats, and the fishery they support, could be at risk if a large-scale mine, such as is described in PLP's Wardrop report, were constructed to extract metals from the Pebble deposit (Wardrop 2011).

Unfortunately, the underlying data supporting these estimates and associated wetland maps have not been released by PLP, making it impossible for reviewers to assess the validity of the estimates of reach and extent of wetlands and aquatic habitats. Inasmuch as detailed analyses of presence or absence of wetlands were made at 865 sample sites within a 29,430-acre mine mapping area (roughly 1 plot for every 34 acres), the maps are extrapolations from point samples where these detailed data were collected to much larger areas where such data were not collected. Without the supporting field data for review, it is not possible to confirm the findings for those limited data collection points where evidence of vegetation, soil, and hydrology field indicators were recorded.

Background

At Bristol Bay Native Corporation's request, I reviewed several chapters of the EBD for the proposed Pebble Project in southwest Alaska. I am a former National Wetlands Expert for the U.S. Environmental Protection Agency (EPA) who has spent over 30 years engaged in permitting issues associated with Section 404 of the Clean Water Act (CWA). My comments focus primarily on CWA regulatory issues associated with discharges of dredged or fill material into regulated waters of the United States, including wetlands.

William Riley, a former mining coordinator for EPA, and I addressed these issues previously in a report titled "Mining the Pebble Deposit: Issues of 404 Compliance and Unacceptable Environmental Impacts" (Riley and Yocom 2011). The EBD chapters were not available for review when that report was prepared. As such, this review of selected EBD chapters has two primary purposes.

First, the information in the reviewed EBD chapters was accepted at face value, to assess whether this additional information, if verified, would have fundamentally changed the assessments and conclusions reached in our report (Riley and Yocom 2011); it did not. As stated by PLP's wetland consultants in EBD Chapter 14, the extent of wetlands mapped by PLP within its mine mapping area is greater than that mapped by the National Wetlands Inventory. Inasmuch as our report (Riley and Yocom 2011) utilized these National Wetland Inventory maps as a means of estimating the potential reach and extent of wetland and aquatic habitats, PLP's wetland estimates would serve to augment rather than lessen the environmental concerns our report raises.

Second, I attempted to assess the validity of the conclusions reached within the EBD chapters regarding the reach and extent of regulated waters of the United States in areas likely to be affected directly or indirectly by regulated discharges associated with proposed mining of the Pebble ore deposit. As I describe below, this effort was hampered by the unavailability of PLP's underlying data.

Objectives

Federal review of the potential environmental impacts of regulated activities in areas containing lakes, rivers, streams, and/or adjacent wetlands is often tied, to a significant degree, to the need for federal authorization pursuant to Section 404 of the CWA. This section of the statute regulates discharges of dredged or fill material into the "waters of the United States," including wetlands. In addition, federal regulations provide that "waters" classified as wetlands, riffle-and-pool complexes, and vegetated shallows are considered "special aquatic sites" under the CWA regulations Title 40 Code of Federal Regulations, Part 230 (40 CFR 230.40-45), and losses or degradation of such areas are considered to be particularly adverse environmental impacts. Accordingly, the reach and extent of such areas are important to understanding the potential impacts of constructing a large-scale mining operation, such as is being proposed for extracting copper and other minerals from the Pebble ore deposit.

My primary focus in reviewing the EBD chapters was to assess the potential reach and extent of wetlands and other "waters of the United States" that might be filled or adversely affected by mining the Pebble ore deposit. Wetlands, as regulated under the CWA, are defined as "those areas inundated or saturated by surface or ground water at a frequency and duration to support, and under normal circumstances do support, a prevalence of vegetation typically adapted to life in saturated soil conditions" [40 CFR 230.3(s)(7)]. For federal regulatory purposes, wetlands are identified and delineated using a combination of mandatory criteria for vegetation, soils, and hydrologic regimes in the upper part of the soil profile. Accordingly, this review focuses on those chapters of the EBD that seemed likely to contain relevant information regarding the reach and extent of wetlands and other potentially regulated waterbodies in the vicinity of the Pebble ore deposit.

Review of Environmental Baseline Document Chapters Related to Wetland Delineation

In determining the reach and extent of such wetland areas, federal wetland delineation methodologies require the presence of hydrophytic vegetation, hydric soils, and wetland hydrology in most years (Environmental Laboratory 1987). Accordingly, I reviewed several EBD chapters to assess what PLP consulting teams reported observing in areas that may be affected by proposed mining activities.

In addition, PLP states that its "*wetlands study builds on information from other chapters in the Pebble EBD, including soils (Chapter 5), surface water hydrology (Chapter 9) and vegetation (Chapter 13)*" (see: http://www.pebbleresearch.com/ebd/bristol-bay-bio-env/chapter-14/). In an effort to assess the findings in Chapter 14 in the absence of the supporting field data, these chapters were also reviewed for this report, as well as Chapter 6 (Geotechnical Studies, Seismicity, and Volcanism – Bristol Bay Drainages) and Chapter 8 (Groundwater Hydrology – Bristol Bay Drainages).

Soils (Chapter 5)

The EBD chapter on soils reviews a 1979 exploratory soil survey prepared by the U.S. Soil Conservation Service (presently the USDA National Resources Conservation Service [NRCS]), and a more detailed 1965 soil survey of the Nondalton village area. The exploratory soil survey is a reconnaissance-level survey that mapped only 4 soil types within the entire mine study area; this scale of soils mapping is inappropriate for wetland delineation work. For example, the areas of the Pebble deposit and the nearly flat areas of marsh that are south of the deposit are mapped in the 1979 survey as "*Typic Cryandepts, very gravelly, hilly to steep association*" (Chapter 5, Figure 5-1). We know from PLP's geotechnical and groundwater hydrology studies (Chapters 6 and 8) that much of this area includes peat deposits (soils classified as histosols).

All of the soils in PLP's Area A and Area G are also described as Typic cryandepts, as are those on the adjacent mountains. Clearly this soil type is not what PLP found in its geotechnical studies within these areas (Chapter 6), and it is unclear why this 30-year-old document was reviewed, other than as a literature review of information developed prior to PLP's environmental studies.

In that regard, it is disappointing that this soils chapter provides no updated findings from the field investigations conducted by PLP's consultants. The wetland delineation teams report in Chapter 14 that they characterized the soils for at least 865 locations within the wetland mapping area, and presumably extrapolated their observations in the mapping of areas that were believed to be wetlands, uplands, or combinations/mosaics of wetland and upland habitats. None of this contemporary information is included in the soils chapter of the EBD.

Similarly, PLP reports that for the overall 249,414-acre mine study area "*Scientists gathered data at 16,947 sites, recording information on vegetation, soils and hydrology at each location*" (see: http://www.pebbleresearch.com/ebd/bristol-bay-bio-env/chapter-14/). With this many data points, it is disappointing that Chapter 5 is limited to an out-of-date literature review, rather than an actual presentation of the environmental baseline data that PLP collected.

Groundwater Hydrology (Chapter 8)

PLP's chapter on groundwater hydrology includes hundreds of pages of drilling logs for groundwater assessments throughout the mine mapping area. These include descriptions of the soils and soil moisture content in the upper part of the soil profile, including the presence of "peat[1]." Such information provides evidence that wetland conditions may be present, inasmuch as organic soils are likely hydric soils, and wet conditions in the upper part of the soil profile may be indicative of the presence of wetlands hydrology.

Figure 1 shows Frying Pan Lake, south of the Pebble ore deposit and the location of three drill sites for which drilling logs are included in Chapter 8. All three of these drilling sites are in areas delineated by PLP consultants as wetlands in Chapter 14. The drilling logs report that the upper portion of the soil profile is composed of peat at all three sites, ranging in depth from 4 feet to 11.5 feet. The findings from these drilling logs therefore appear to be consistent with the areas where the drill sites are located to be wetlands. It would be preferable that PLP had provided its field data rather than expect reviewers to attempt to piece such information together.

Vegetation (Chapter 13) and Wetlands and Waterbodies (Chapter 14)

Chapters 13 and 14 are reviewed together, inasmuch as 1) they were prepared by the same two consulting firms, 2) the vegetation studies are integral to the assessment of wetlands, and 3) the mapping of wetlands on aerial photographs relies primarily on "signatures" developed on the basis of vegetation community structures.

Chapter 14 describes the methods used to determine whether mandatory federal criteria are present or absent at sampling points from which PLP extrapolated its estimates of the reach and extent of potentially regulated wetlands and waterbodies within its "Mine Mapping Area" and "Transportation-corridor Study Area." None of the actual field data that were collected and interpreted are presented. Accordingly, it is not possible to systematically evaluate the maps of wetlands and waterbodies that make up the bulk of the chapter.

For the purposes of CWA jurisdiction and regulation, wetlands are delineated and mapped on the basis of three primary factors. Wetlands must be vegetated, and dominated with emergent vascular plants (with some exceptions in Alaska) that are considered hydrophytic (adapted for life in saturated soil conditions).

Similarly, to be a regulated wetland, the hydrophytic vegetation community must be growing on soils that have field indicators of the mandatory criterion of being "hydric," and field indicators of mandatory hydrologic conditions of inundation or saturation in the upper part of the soil profile in most years. In the absence of the actual field data for PLP's wetlands estimates, it is

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[1]It is likely that the drilling teams used this term to describe organic deposits of any depth, rather than how the term "peat" is defined in soil taxonomy with a minimum depth of 16 inches (see NRCS , 2010).

not possible to assess the presence or absence of indicators of these criteria for any particular mapped area, though it is possible to evaluate PLP's stated methodologies for consistency with existing federal methodologies and guidance.

Reported wetland delineation data were collected from 2004 through 2008. In 2007, the United States adopted regional delineation methodologies for Alaska that are described in the US Army Corps of Engineer's (USACE's) 2007 Alaska Regional Supplement to the Corps 1987 Wetlands Manual (USACE 2007). It is unclear whether the PLP data collected in 2004 through 2007 were revisited in light of this guidance, but it appears that they may not have been and, as such, may have led to an underestimation of the reach and extent of wetlands within the mine mapping area.

For example, the Regional Supplement (USACE 2007) notes that soil pits should be dug deeper in areas with dark upper layers because organic material can mask the redoximorphic features -- the Regional Supplement recommends 40-inch or deeper holes to get below this area of organic influence. The PLP wetlands work, however, notes that dark upper layers without redoximorphic features were considered non-hydric, and that the soil pits were generally 24 inches deep.

PLP's consultants do report a number of areas that they identified as unregulated uplands where PLP recorded field indicators for two of the required three wetland factors (hydrophytic vegetation, hydric soils, and/or wetlands hydrology) with the third factor missing. If any of these sites were determined to lack hydric soils indicators, such as redoximorphic concentrations, where, in fact, these indicators may have been present at appropriate soil depths, the conclusions reached by PLP's consultants regarding presence of wetlands may be incorrect; however, it is impossible to tell without the field data.

Similarly, if the sampling was done during what the Regional Supplement (USACE 2007) describes as the "dry season" for Alaska (or during an unusually dry month), the absence of field indicators of wetlands hydrology may possibly have led to false negatives with regard to the presence of wetlands. Inasmuch as no information is given in the EBD chapters about the specific dates on which wetlands field data were collected, it is not possible to assess whether these concerns are warranted. This information is likely included as part of the field data that were collected and recorded by PLP consultants, and if PLP expects its reports to have utility to outside parties, this information should be made available, much as it would be required if the wetland delineation maps were submitted to the USACE for a formal determination of jurisdiction.

Presence or Absence of Hydrophytic Vegetation

In Chapter 13 (Vegetation, Bristol Bay Drainages), PLP's consultants report the most common species found within the overall mine mapping area (Chapter 13, Appendix 13.1C); these species are shown in Table 1. For this review, I also added the Alaska regional wetland indicator status (Reed 1988) for each species. The indicator status reflects the relative frequency with which a species is expected to be found growing in wetlands throughout its range in Alaska.[2] Plant species that are not listed are generally to be considered upland species (growing in wetlands less than 1% of the places such species are found growing in Alaska)[3].

A total of 70 plants are identified to the species level by PLP's consultants (Table 1). Three additional plants are listed by PLP where only the genus is identified, as well as several non-vascular plants (mosses and lichens); these are not included herein, as these normally cannot be used for wetland delineation purposes. One of the identified species is listed, but is given no indicator (NI) status, indicating that there is insufficient information available to place it in a particular category (Reed 1988). Three of the 70 species in Table 1 are not on the list of wetland plants and therefore are to be considered upland (UPL) species. Another unlisted species (*Viola epipsila ssp. repens,* dwarf marsh violet) has been identified by the USACE as a plant that should not be considered an upland species in Alaska (USACE 2007).

In summary, all but three of the 70 species (96%) that PLP reports as the most common vegetation in the mine mapping area are known to occur in wetlands in Alaska with sufficient frequency to be listed on the Alaska list of wetland species. Of the 65 species for which a wetland indicator status has been assigned for the Alaska region, 49 (75%) are classified as FAC, FACW, or OBL, all of which would be considered hydrophytic species where they make up 20% or more of the relative cover of vegetation (dominant species) at sites where wetland jurisdictional data are being collected.

Whereas Chapters 13 and 14 provide little specificity with regard to how these 70 common species are distributed across the mine mapping area, the list itself suggests that, more often than not, the presence or absence of wetlands would have been made on the basis of the presence or absence of field indicators of hydric soils and/or wetlands hydrology criteria rather than on indicators of hydrophytic vegetation. Inasmuch as hundreds of wetland and hydrogeomorphic maps in Chapter 14 are based upon primarily on vegetation signatures, it is critical that reviewers understand how areas of uplands are distinguished from areas of wetlands, particularly if most of the species of vegetation reported within the study areas are known to occur in wetlands with at least some frequency throughout their range in Alaska.

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[2]For example, OBL refers to "obligate" species that would be expected to be growing in wetlands rather than uplands in more than 99% of the places that plant occurs in Alaska. Facultative -wetland (FACW) species have a relative-frequency estimate of growing in wetlands rather than uplands more than 66% throughout their range in Alaska. Facultative (FAC) species are estimated to be in wetlands between 33% and 66% of their range (these plants are adapted to compete relatively equally in wetlands or uplands in Alaska). Facultative -upland (FACU) species are estimated to occur in uplands more often than in wetlands, with an estimated occurrence in wetlands less than 33% of the places those species can expected to be found growing in Alaska.

[3]Generally, regional wetland plant lists do not include the vast majority of vascular plants growing in a region. Wetlands tend to be harsh environments that require special adaptations for species to survive periodic or lo ng-term saturation and anaerobic conditions in the root zone. Those species that are listed have been reported growing in wetlands with sufficient frequency to be listed, and the dominant presence of such species, even those considered facultative-upland (FACU – frequency of occurrence as high as 33% throughout its range in a region) is indicative that wetlands may be present if soil and hydrology criteria are also met.

Unfortunately, the data showing the presence or absence of soil and hydrology indicators for different vegetation signatures are not provided for review. Similarly, the EBD chapters include bibliographical references that are also not available to outside reviewers.

For example, Chapter 13 (Vegetation) and Chapter 14 (Wetlands and Waterbodies), cite three unpublished reports regarding a "Mine Site Vegetation Type Photo Signature Guide." Presumably these reports describe what particular color and texture patterns and/or landscape positions were used to characterize areas containing 1) wetlands, 2) primarily wetlands, 3) primarily uplands, or 4) uplands. However, without this information, it is not possible to know the basis for why some vegetated areas that appear similar on PLP's aerial photographs are mapped as wetlands in some areas and as uplands elsewhere.

In mapping such areas for wetland properties, a necessary presumption is that particular areas of an aerial photograph that have similar color and texture in similar landscape positions will have similar vegetation, as well as underlying soil and hydrologic conditions; infrared photography can be useful in understanding hydrologic differences between vegetative communities, but it is unclear whether any contemporary infrared photographs were utilized. Nevertheless, it is not possible for outside reviewers to assess the reliability of the PLP's wetland maps without knowing how the photographic signatures were determined, or the statistical confidence, if any, with which these signatures were extrapolated to the majority of the mapped areas that were not, in fact directly sampled or field-verified.

Figure 2 shows vegetation communities near the Pebble ore deposit as mapped in Chapter 13. These maps are somewhat confusing because the scale of the maps and the subtlety of the various representative mapping colors make the vegetation communities difficult to distinguish. These communities are somewhat easier to distinguish where they have been further consolidated in Chapter 13 into eight communities for the wetland delineation effort (Figure 3), but the maps cannot be verified without the underlying data.

Indicators of Hydric Soils

Chapter 6 (Geotechnical Studies, Seismicity, and Volcanism – Bristol Bay Drainages) provides evidence that hydric soils and wetland hydrology are present throughout the "Mine Study Area." In the area of the Pebble ore deposit, the geology is described as consisting of "*glacial drift, glaciolacustrine, and glaciofluvial materials with overburden of gravel, sand, silt, and clay*" (Chapter 6, page 6-10). Hydric soils include soils that were laid down by water, such as lacustrine and fluvial deposits, and can include soils in drainage classes that do not drain easily, including silt- and clay-bearing soils (NRCS 2010).

Furthermore, the Pebble East Area is described as having topsoil from zero to approximately 4 feet thick, with some areas of peat deposits up to 2.5 feet thick (Chapter 6, page 6-10). For the purposes of wetland delineation, all organic soils (excluding folists[4]) are considered hydric soils, and an organic layer of more than 16 inches ("peat") would be a hydric soil by definition. The reach and extent of such areas is not provided in Chapter 6, nor is this information provided if and where such areas were encountered by the wetlands consulting teams in Chapter 14.

For Area G (see Wardop 2011), which has been proposed for a tailings storage facility (see Figure 3), Chapter 6 reports that "peat up to 10 feet thick is found in the bottom of the valley with thinner peat found in some poorly drained areas on the valley slopes" (Chapter 6, page 6-13); overburden in the valley bottom of Area G "was up to 15 feet of combined peat, sands, and gravels" (Chapter 6, page 6-14).

Peat is also reported in the a) Pebble East Area, Upper Talarik Creek Area, b) North Fork Koktuli River Area (0.5-[5] to 2-foot-thick layer of organic topsoil – Chapter 6, page 6-12), c) Area G, d) South Fork Koktuli River Area, and e) Area A -Valley Bottom. It is likely that all such areas underlain by peat are wetlands, though the reach and extent of such areas of peat is not shown, and the field data from the wetland delineation teams was not provided. Geotechnical test pits were excavated in the Area A – Valley Bottom, the area where "peat up to 10 feet thick" is described in Chapter 6, but the drilling reports only describe the material beneath the surface layer.[6] Some specific drill sites are shown in Chapter 8 (Groundwater Hydrology) where deep organic surface layers were found (Figure 1 shows drill sites near Frying Pan Lake).

Of course, organic soils (histosols) are only a small subset of soils that are considered hydric or potentially hydric. Most hydric soils are mineral soils that have characteristic properties and indicators by which they are classified (NRCS 2010). Accordingly, the areas where peat deposits are reported are very likely wetland areas, but so too are areas where the water table is at or near the surface[7], as well as areas with thick organic surfaces, redoximorphic depletions,

[4]According to the USACEs' wetland delineation supplement for Alaska, most folists are c omprised of poorly decomposed organic material and usually are found in forested areas with greater than 10 percent slopes (USACE 2007, page 20).

[5]A 0.5-foot-thick layer of organic material is not considered "peat" for wetland delineation purposes. The th ickness of this layer must be 16 inches or greater. A surface organic layer of 8 to 16 inches is considered a "hystic epipedon" and can be considered a field indicator of a hydric soil (Environmental Laboratory 1987).

[6]For example, test pits TP04 -19 and TP04-20 lie north of Frying Pan Lake and south of the Pebble ore deposit. The reported data from these pits list sand and gravel with some silt in TP04 -19 beginning 2.6 feet below the surface and continuing to 9.8 feet, the total depth of the pit. The upp er 2.6 feet of material is not described. For TP04 -20, clay, silt, sand, and some peat lenses are reported beginning 4.6 feet below the surface to 8.9 feet, the total depth of the pit. The upper 4.6 feet of material is not described, but is likely to be organic soil material (peat). Chapter 8 (Groundwater Hydrology) also includes soil boring logs that are useful in assessing the presence of hydric soils. For three drilling sites adjacent to Frying Pan Lake, surface peat deposits from 4 to 11.5 feet thic k are reported (see Appendix 8.1A, pages 437, 442, and 454), all positive indicators of hydric soils.

[7]For western Alaska, the USACE cautions that soil saturation is most likely during May –September. "Saturated organic deposits commonly occur in groundwat er discharge zones in depressions and flats, and extensively across backslopes where restrictive layers (*e.g.*, permafrost, glacial till) in the soil perch water " (USACE 2007, page 31).

redoximorphic concentrations, reduced matrices, reduced sulfur (H_2S), and certain soil colors (Environmental Laboratory 1987 and USACE 2007). Again, without the field data from the wetland delineation teams, it is not possible to systematically review the conclusions drawn about the presence or absence of field indicators of hydric soils, including soil saturation.

The extensive organic layers in the soils in the vicinity of the Pebble ore deposit, and the deep deposits within the drainage proposed for the initial tailings storage facility (Area G) raise some additional questions regarding the fate of this organic material should mining operations commence. This material could be a potentially harmful source of nutrient input to surface waters that could affect biochemical oxygen demand (BOD).

Indicators of Wetlands Hydrology

Chapter 6 (Geotechnical Studies, Seismicity, and Volcanism – Bristol Bay Drainages) provides evidence that wetland hydrology is present throughout the mine mapping area. Throughout the chapter, inundated or saturated soils conditions are described as a piezometric surface above the ground surface and at varying depths below the surface. These results are representative of where test pits were excavated, and are not necessarily representative of any of the named sub-areas where sampling was done.

"Area A – Valley Bottom," described as the area that lies south of the Pebble ore deposit and includes Frying Pan Lake, is described as having a piezometric surface "*above or within 10 feet of the ground surface, evidenced by the numerous swamp/wetland areas in this area….The wet, boggy composition of this area is indicative of a groundwater discharge zone*" (Chapter 6, page 6-17). However, there are no data presented to determine exactly where these conditions were found or their reach and extent.

Wetlands Delineated by PLP's Consultants (Chapter 14)

According to PLP, vegetation, soils, and hydrology data were collected between 2004 and 2008 at 16,947 field sites within an overall 249,414-acre mine study area. Within the 29,429.7-acre "mine mapping area," PLP consultants report collecting data on field indicators of hydrophytic vegetation, hydric soils, and wetland hydrology at 865 study plots, or roughly 1 plot for every 34 acres. PLP reports that additional data, often in the form of photographs, were taken at many additional sites, but that in most cases this additional data did not include detailed observations or measurements associated with wetland field indicators. Within the mine mapping area (exclusive of the transportation-corridor wetland mapping area), PLP reports 9,826 acres (roughly 33% of the overall 29,429-acre mapping area) to be wetlands and/or aquatic habitats.

Figures 4 and 5 show areas containing wetlands as delineated by PLP's consulting teams. These figures are composites that I created for this report from many individual map "tiles" that are presented in Chapter 14. Figure 4 includes the generalized boundary of the Pebble ore deposit that PLP included on its original map tiles. For this report, a portion of the boundary of the proposed mine pit and waste rock disposal areas shown in the Wardrop report has also been added. It is clear from this figure that if the PLP's wetland delineation maps are correct, large areas of wetlands, streams, and open water areas in the upper portion of the South Fork Koktuli River and Upper Talarik Creek would be destroyed if the mine pit and waste rock areas were constructed for the minimum-sized 25-year mining proposal described in Wardrop (2011).

Similarly, Figure 5 shows the areas containing wetlands, streams, and open water habitats mapped by PLP's consulting teams covering a drainage (Area G) that has been proposed as the site of a tailings storage facility (Wardrop 2011). This figure is also a composite of individual map tiles presented as separate figures in Chapter 14; for this report, the approximate boundary of the tailings storage facility described in Wardrop has been added. Again, it is clear from this figure that if the PLP maps are correct, large areas of wetland and aquatic resources would be destroyed if a tailings impoundment were constructed at this site. It is also noteworthy that Chapter 15 (Fish and Aquatic Invertebrates) documents that the unnamed tributaries to the North Fork Koktuli River that drain Area G include salmon spawning and rearing habitat.

In spite of what appear in Figures 4 and 5 to be extensive areas of wetland and aquatic habitats in areas proposed for an open pit mine and a tailings storage facility, it is not possible to determine whether these maps are an accurate representation, an underestimate, or an overestimate of the reach and extent of these habitats without reviewing the underlying data.

In an effort to gain some perspective on the potential reliability of the maps for this report, I compared the conditions reported in soil borings at drill sites in Chapter 8 with the wetland maps in Chapter 14. Figure 6 shows the locations of a portion of the drill sites in Chapter 8 overlain on the subset of the Chapter 14 wetland maps that were composited for Figure 4 above. The drill sites shown in Figure 6 are all of those for this mapped area for which drilling logs were included in an appendix to Chapter 8.

For the purpose of making this comparison, I categorized these drill sites in advance into four general categories based my interpretation of how the drilling logs describe the upper part of the soil profile:

1. Where more than the top 2 feet of soil are described as organic material, and/or where there was no recovery of a soil boring due to perceived wetness or organic content, the site is shown as a solid green circle.
2. If the upper layer of the soil was less than 2 feet of organic material, but was underlain by what was described as silt, clay, or silty sand, the drill site is shown as a green unfilled circle (I presumed the soil might be poorly drained and potentially hydric).
3. Where there was less than a foot of organic material and/or silty gravel, a red unfilled circle marks the drill site.
4. Where the upper part of the soil profile was sand or sand and gravel, a solid red circle marks the spot.

I used these categories to generalize what I considered to be a decreasing likelihood that hydric soils and wetland hydrology might be present at the drill site, and assigned these categories before examining the locations of these drill sites on PLP's wetland maps.

I found that, in general, there appeared to be a reasonably good correlation between the descriptions in the drilling logs and how wetland areas were mapped (assuming, of course, that the coordinates for the drill sites and wetlands were mapped similarly). However, this spot-checking effort cannot, nor is it intended to, substitute for reviewing PLP's actual wetland delineation data, and it lends nothing to the question of whether the actual boundary lines between wetland types and upland areas are valid.

Potential Inconsistencies in Wetlands Mapping

The EBD chapters are electronic documents that are copy protected. As such, the underlying aerial photography cannot be examined to inspect what the photographs reveal underneath colored layers of mapped wetlands, transitional areas, or uplands. The EBD chapters would be more useful to reviewers if the underlying photography is provided separately so that side-by-side comparisons could be made. Furthermore, the specific dates upon which the aerial photographs were taken are not provided, but should be. Ideally, photographs should be selected, where possible, from dates during the growing season in a year of normal precipitation; but, in any event, the dates of photographs should be given.

Nevertheless, it is possible to compare vegetation color and texture outside of the boundary of the mine mapping area with the adjacent wetland/upland mapped polygon on the inside the boundary. Figure 7 shows areas mapped in the vicinity of Frying Pan Lake, which lies south of the Pebble ore deposit. I chose to inspect this area because in August 2011, I walked some areas on the western side of Frying Pan Lake. Whereas, I did not do any sampling of vegetation or soils during my short visit nor did I dig any pits to examine indicators of hydrology, I did observe areas dominated with hydrophytic vegetation, and soils with thick organic surfaces that were saturated at the surface.

The wetland mapping area around Frying Pan Lake does not extend very far laterally, and the variously colored or cross-hatched mapped polygons can be compared to the contiguous adjacent areas of the aerial photographs that were not mapped. Figure 7 identifies areas on the unmapped portion of the photographs that appear to have similar color and texture, as well as areas with apparent drainage features, but where these areas are mapped as wetland and aquatic areas in some cases, but upland habitats in others. I did not conduct a "tile-by-tile" inspection of the areas that are mapped in Chapter 14, but my inspection of the area where I walked, and the potential inconsistency with which similarly-appearing areas are mapped differently in Chapter 14, raise questions that can best be answered by seeing the field data collected by the PLP consultants and the vegetation mapping protocols that are described in internal reports that have not been provided by PLP.

Conclusions

It is clear that consultants for PLP collected a great deal of data, summarized in roughly 30,000 pages of EDB reports. Unfortunately, the summaries related to wetlands and waterbodies, though voluminous, cannot be readily evaluated or verified without the underlying data.

Accordingly, it is not possible to determine whether any of the areas mapped by PLP as wetland and aquatic areas in Chapter 14 are, in fact, regulated wetland and aquatic areas. As such, the extent of wetlands and aquatic habitats, particularly those that could be threatened by large-scale mining of the Pebble deposit cannot be verified without these data.

Accepted at face value, the EBD summaries show over 9,800 acres of wetlands, shallow open water areas, and streams in the vicinity of the Pebble ore deposit and adjacent drainages that may be sites of proposed tailings storage facilities. Whether PLP's estimates of potential "waters of the United States," including wetlands are accurate, underestimates, or overestimates cannot be determined. As such, the summarized data has far less value than if the underlying data had been provided, and these mapped estimates of wetland and aquatic sites cannot be relied upon for scientific or regulatory purposes in my opinion.

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Table 1: Common species of vegetation reported from Mine Mapping Area by PLP				
	Wetland Indicator (AK)	Latin Name	Common Name	Comments
TREES (smaller individuals of some of these species were also reported in Chapter 13 as shrubs)				
1	FACU	*Betula papyrifera s.l.*	Paper birch	FACU species that may dominate in certain Alaska wetland situations include paper birch. (ERDC 2007, page 84)
2	FACU	*Picea glauca*	White spruce	FACU species that may dominate in certain Alaska wetland situations include white spruce. (ERDC 2007, page 84)
3	FACW	*Picea mariana*	Black spruce	
4	FACU	*Populus balsamifera*	Cottonwood	
5	FAC	*Salix alaxensis*	Feltleaf willow	
SHRUBS				
6	FAC	*Alnus sinuata*	Sitka alder	
7	OBL	*Andromeda poIifolia*	Bog rosemary	
8	FAC	*Arctostaphylos alpina*	Alpine bearberry	
9	FAC	*Betula nana ssp.* exilis	Dwarf birch	
10	FAC	*Empetrum nigrum*	Black crowberry	
11	FACW	*Ledum decumbens*	Narrow-leaf Labrador tea	
12	UPL	*Loiseleuria procumbens*	Alpine azalea	
13	FAC	*Potentilla fruticosa*	Shrubby cinquefoil	syn: genus *Dasiphora*
14	FACU	*Ribes glandufosum*	Skunk currant	
15	FACW	*Salix arbusculoides*	Little-tree willow	
16	FAC	*Salix arctica*	Arctic willow	
17	FAC	*Salix barclayi*	Barclay willow	
18	FACW	*Salix* fuscescens	Alaska bog willow	
19	FAC	*Salix glauca*	Grayleaf willow	
20	FACW	*Salix pulchra*	Diamond leaf willow	syn: *Salix planifolia* (FACW)
21	FAC	*Salix reticulata*	Netleaf willow	
22	FAC	*Salix richardsonii*	Richardson's willow	
23	FAC	*Spiraea beauverdiana*	Beauverd spirea	
24	OBL	*Vaccinium oxycoccos*	Small cranberry	
25	FAC	*Vaccinium uliginosum*	Bog blueberry	
26	FAC	*Vaccinium vitis-idaea ssp. minus*	Mountain cranberry	
27	FACU	*Viburnum edule*	Squashberry	
HERBS				
28	FACU	*Achillea borealis*	Yarrow	syn: *Achillea millefolium L. var. borealis*
29	FAC	*Aconitum delphiniifolium*	Monkshood (larkspur-leaf)	
30	FACU	*Angelica lucida*	Seawatch angelica	
31	UPL	*Artemisia arctica*	Mountain sagewort	
32	FAC	*Athyrium filix-femina ssp. cyclosorum*	Subarctic lady fern	
33	FAC	*Calamagrostis canadensis*	Bluejoint reedgrass	
34	OBL	*Carex aquatilis*	Water sedge	
35	FAC	*Carex bigelowii s.l.*	Bigelow's sedge	
36	FACW	*Carex microchaeta s.l.*	Small-awned sedge	
37	FACW	*Carex nesophila*	Bering Sea sedge	
38	FACW	*Carex* stylosa	Long-style sedge	
39	FAC	*Cornus suecica*	Swedish dwarf dogwood	
40	FACU	*Dryopteris dilatata ssp. americana*	Mountain woodfern	syn: *Dryopteris expansa* (FACU)

Table 1: Common species of vegetation reported from Mine Mapping Area by PLP (cont.)				
	Wetland Indicator (AK)	Latin Name	Common Name	Comments
41	FACU	*Epilobium angustifolium*	Fireweed	syn: genus *Chamerion*
42	OBL	*Epilobium palustre*	Marsh willow-herb	
43	FACU	*Equisetum arvense*	Field horsetail	FACU species that may dominate in certain Alaska wetland situations include field horsetail. (ERDC 2007, page 84)
44	OBL	*Equisetum fluviatile*	Water horsetail	
45	FACW	*Equisetum pratense*	Meadow horsetail	
46	FACU	*Equisetum sylvaticum*	Woodland horsetail	
47	FACU	*Eriophorum angustifolium*	Narrow-leaf cottongrass	
48	OBL	*Eriophorum scheuchzeri*	Scheuchzer's cottongrass	
49	FACW	*Eriophorum vaginatum*	Tussock cottongrass	
50	FAC	*Festuca altaica*	Rough fescue	
51	FACU	*Galium boreale*	Northern bedstraw	
52	UPL	*Geranium erianthum*	Woolly geranium	
53	FACU	*Gymnocarpium dryopteris*	Oak fern	
54	FACU	*Heracleum lanatum*	Cow parsnip	syn: *Heracleum maximum*
55	FAC	*Lycopodium annotinum s.l.*	Stiff clubmoss	
56	NI	*Moehringia lateriflora*	Grove sandwort	
57	FACW	*Petasites frigidus s.l.*	Arctic sweet coltsfoot	
58	FAC	*Poa palustris*	Fowl bluegrass	
59	FAC	*Polemonium acutiflorum*	Sticky tall Jacob's-ladder	
60	OBL	*Potentilla palustris*	Marsh cinquefoil	syn: *Comarum palustre*
61	FAC	*Pyrola asarifolia*	Pink wintergreen	
62	FAC	*Rubus arcticus s.l.*	Arctic raspberry	
63	FACW	*Rubus chamaemorus*	Cloudberry	
64	FACW	*Rumex arcticus*	Arctic dock	
65	FACW	*Sanguisorba canadensis*	Canada burnet	syn: *Sanguisorba stipulate* PLP Vegetation Chapter 13 lists these as separate species.
66	FACU	*Solidago multiradiata*	Mountain goldenrod	
67	FAC	*Streptopus amplexifollus*	Clasp-leaf twisted-stalk	
68	FAC	*Trientalis europaea s.l.*	European starflower	
69	FAC	*Valeriana capitata*	Clustered valerian	
70	NL*	*Viola epipsila ssp. repens*	Dwarf marsh violet	*Some species not listed by Reed (1988) should not be assumed to be upland plants, including *Viola epipsila* ssp. *repens*. (ERDC 2007, page 10)

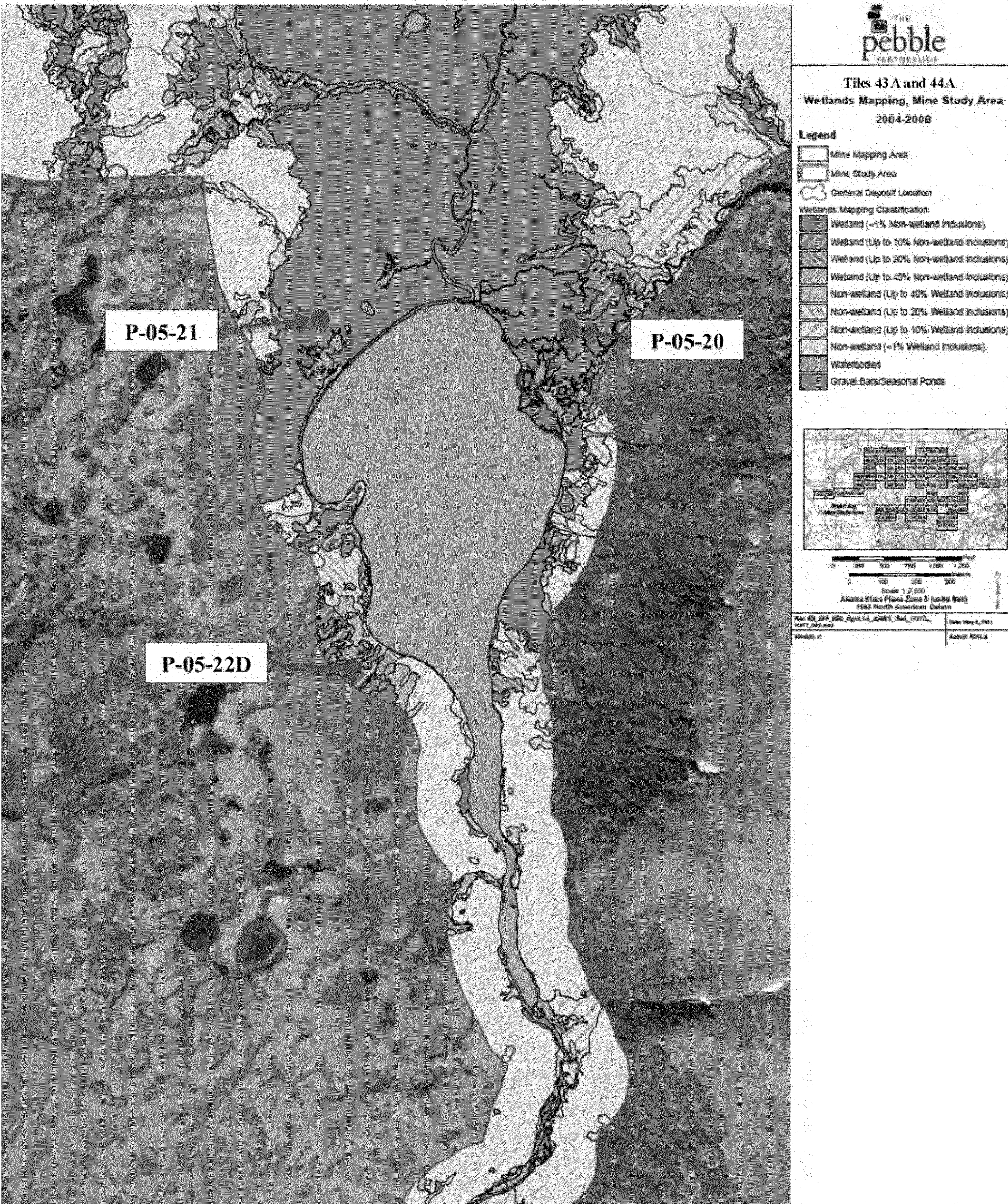


Figure 1. Approximate location (blue circles) of groundwater hydrology sampling sites for which soil boring logs are shown in Chapter 8. These locations are overlain on PLP's wetland maps (Chapter 14) for the Frying Pan Lake area. Four feet of peat are reported at the surface of sites P-05-21 and P-05-22D, and 11.5 feet of peat are reported at drill site P-05-20.

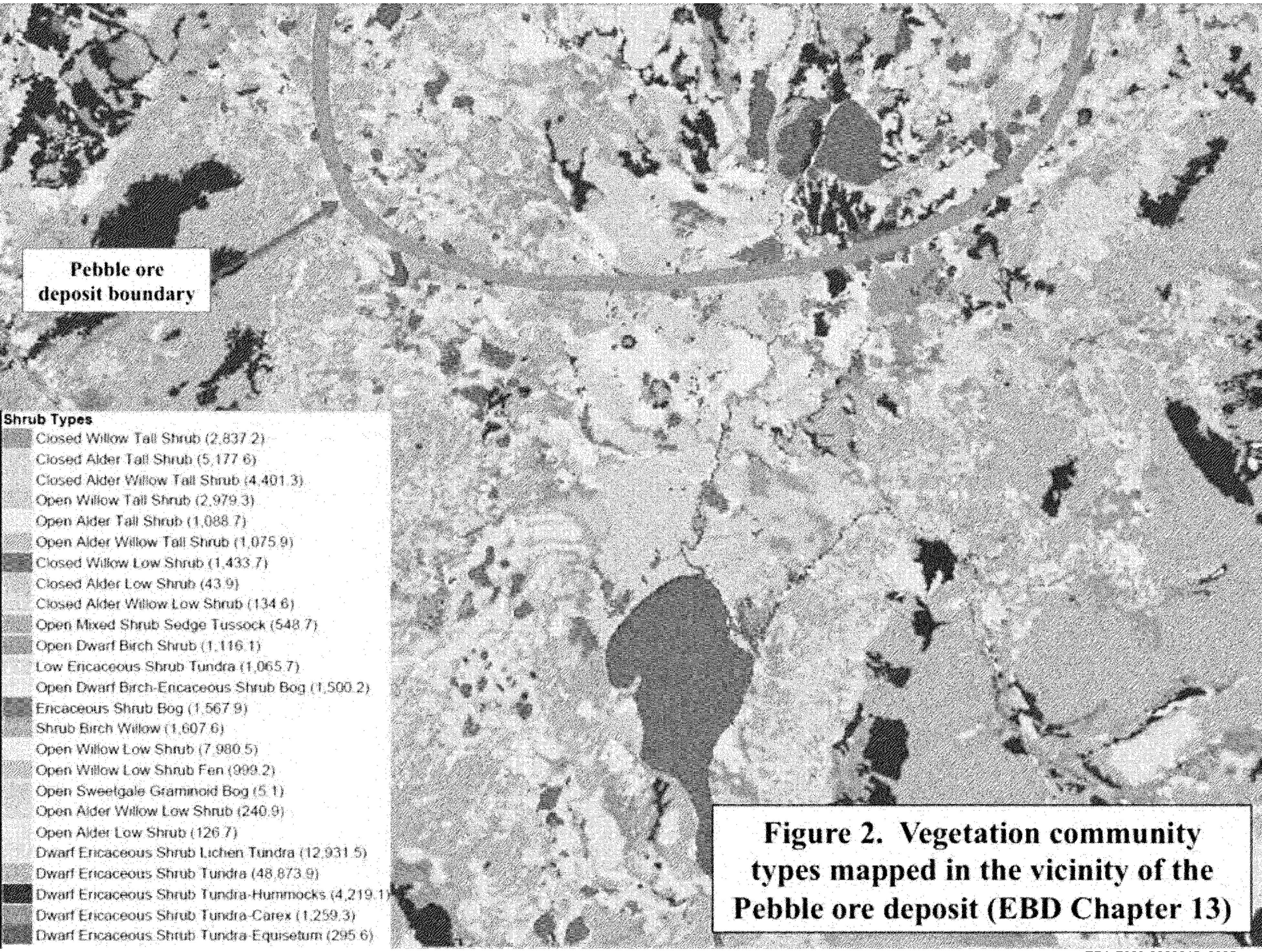
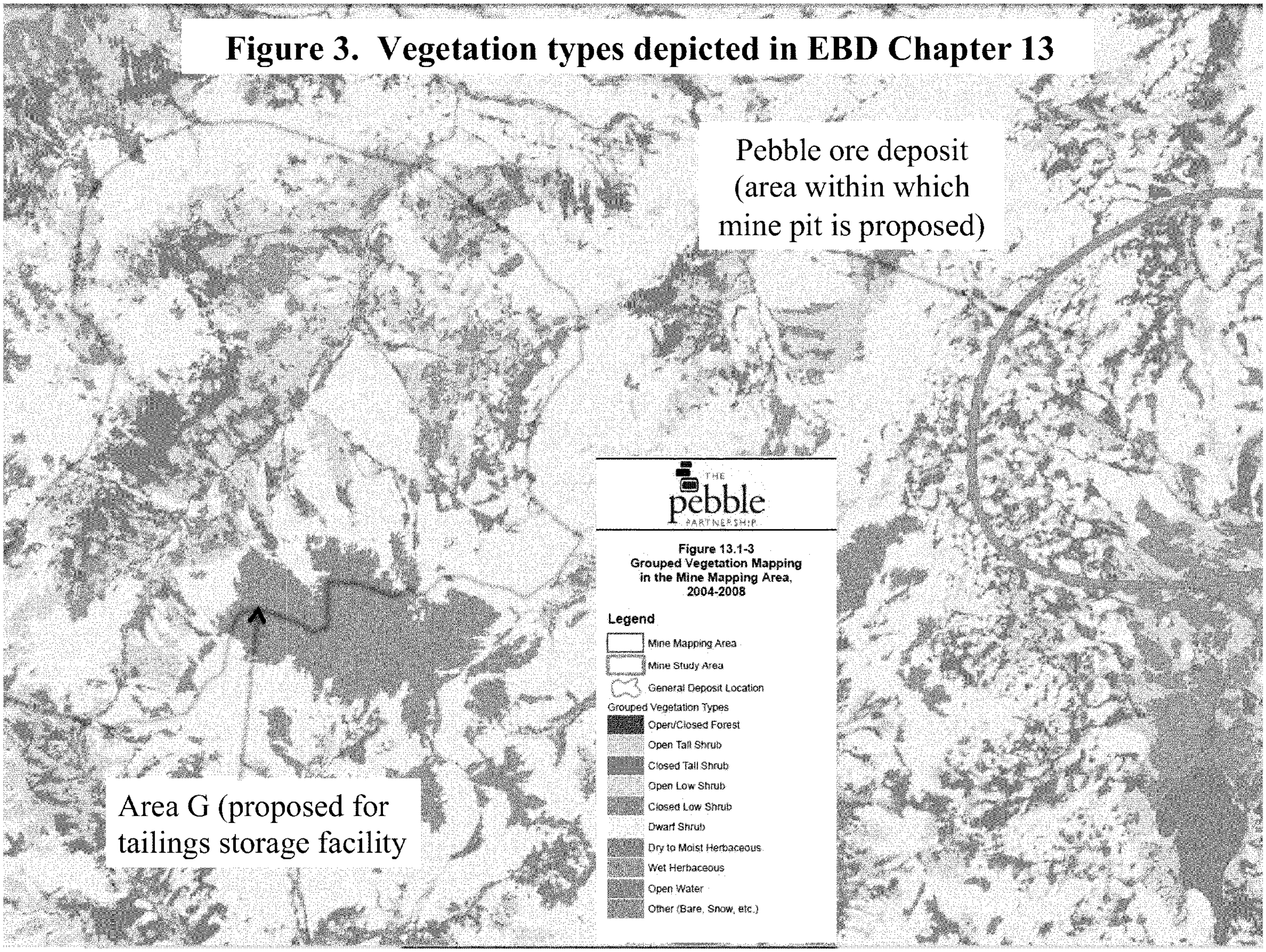


Figure 2. Vegetation community types mapped in the vicinity of the Pebble ore deposit (EBD Chapter 13)

Figure 3. Vegetation types depicted in EBD Chapter 13



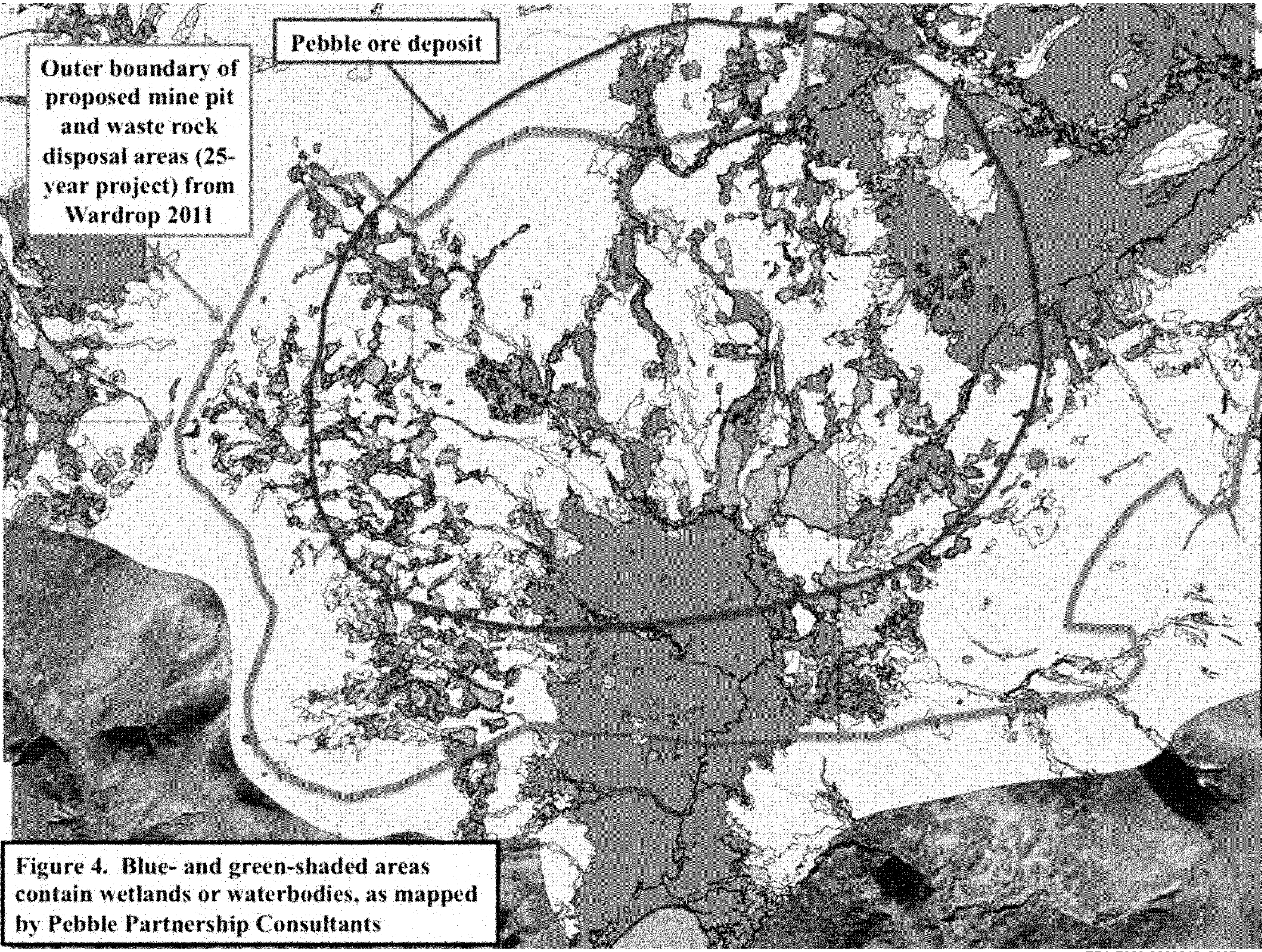


Figure 4. Blue- and green-shaded areas contain wetlands or waterbodies, as mapped by Pebble Partnership Consultants

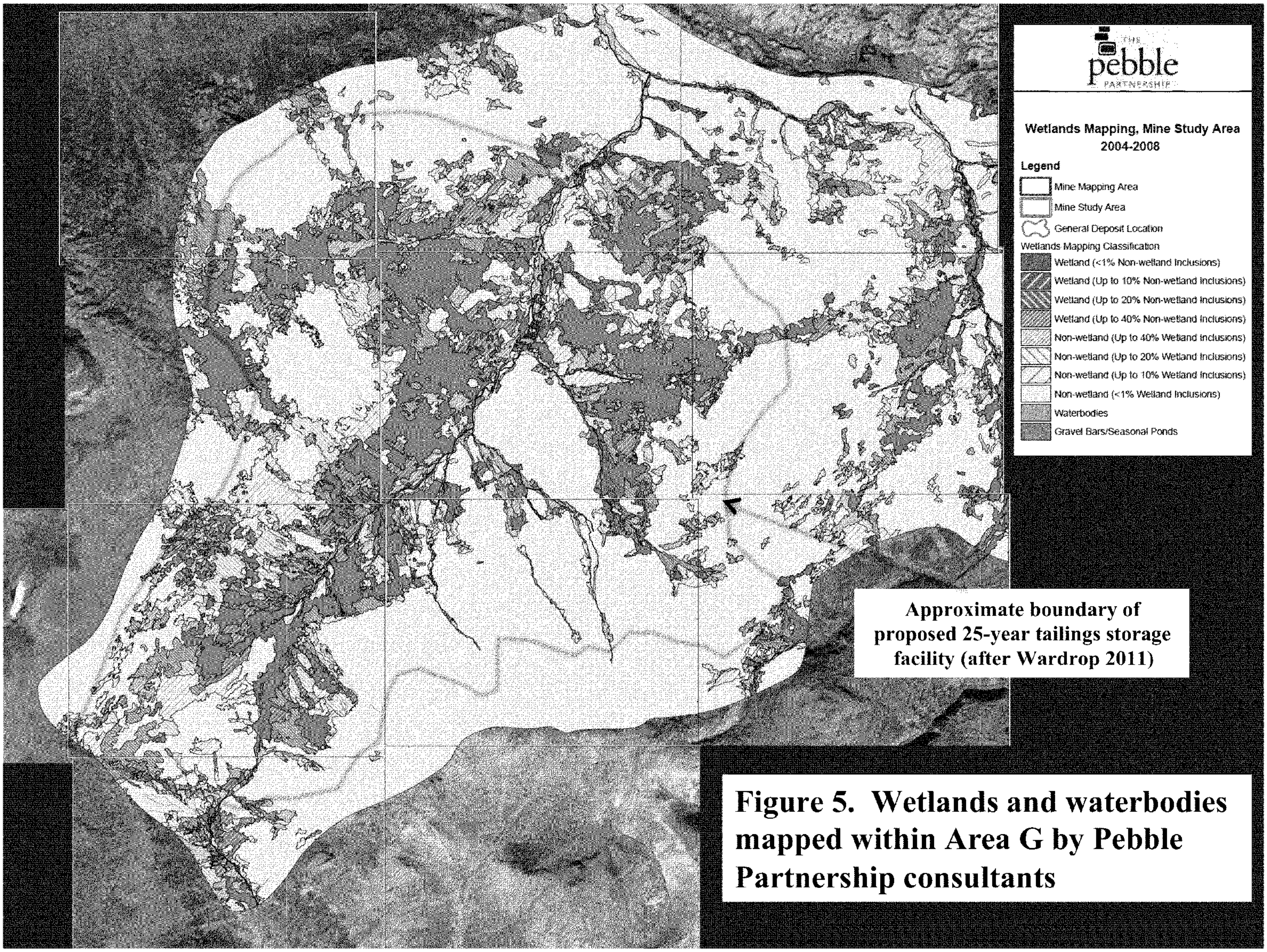


Figure 5. Wetlands and waterbodies mapped within Area G by Pebble Partnership consultants

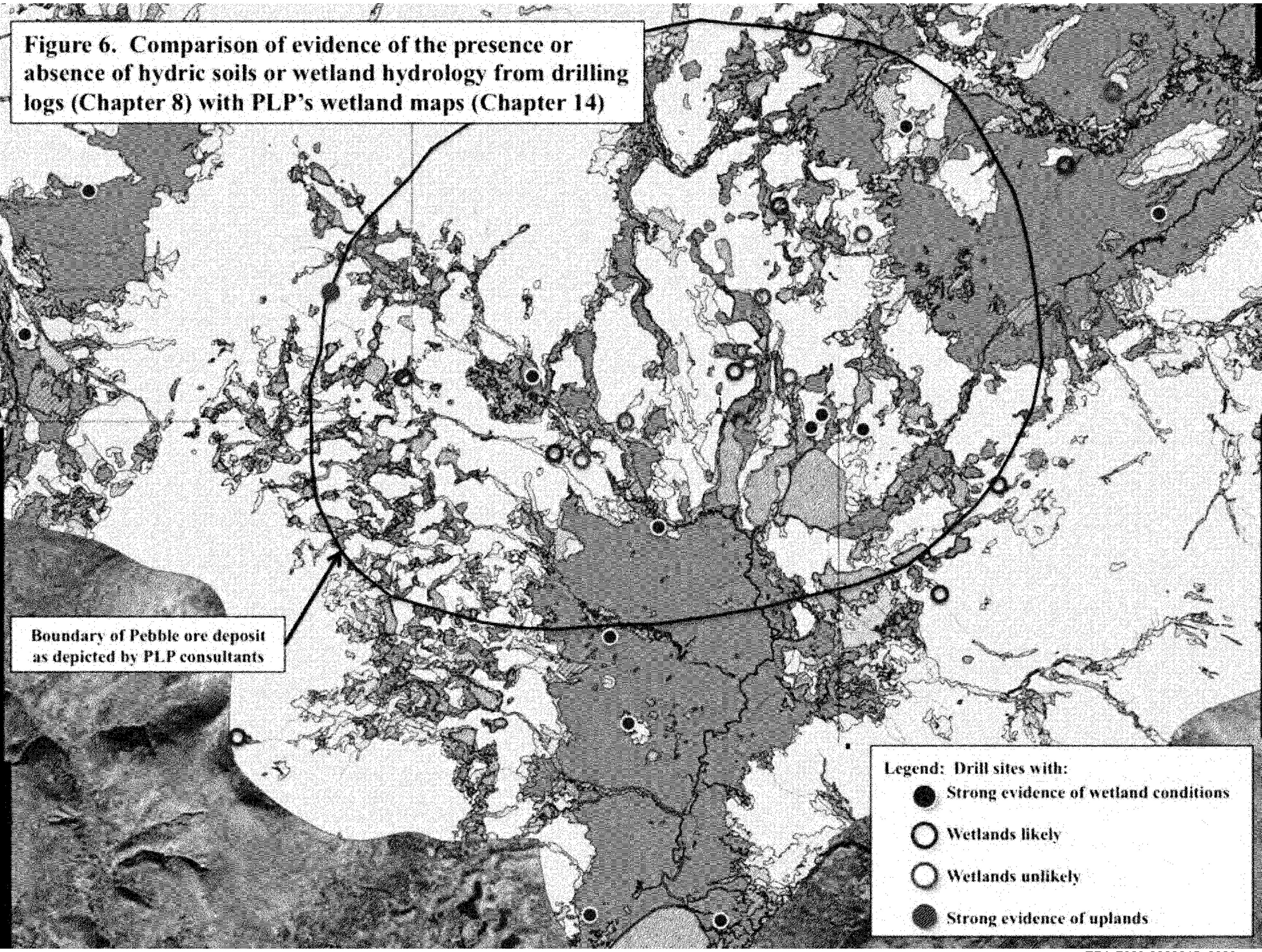


Figure 6. Comparison of evidence of the presence or absence of hydric soils or wetland hydrology from drilling logs (Chapter 8) with PLP's wetland maps (Chapter 14)
Boundary of Pebble ore deposit as depicted by PLP consultants
Legend: Drill sites with:
Strong evidence of wetland conditions
Wetlands likely
Wetlands unlikely
Strong evidence of uplands

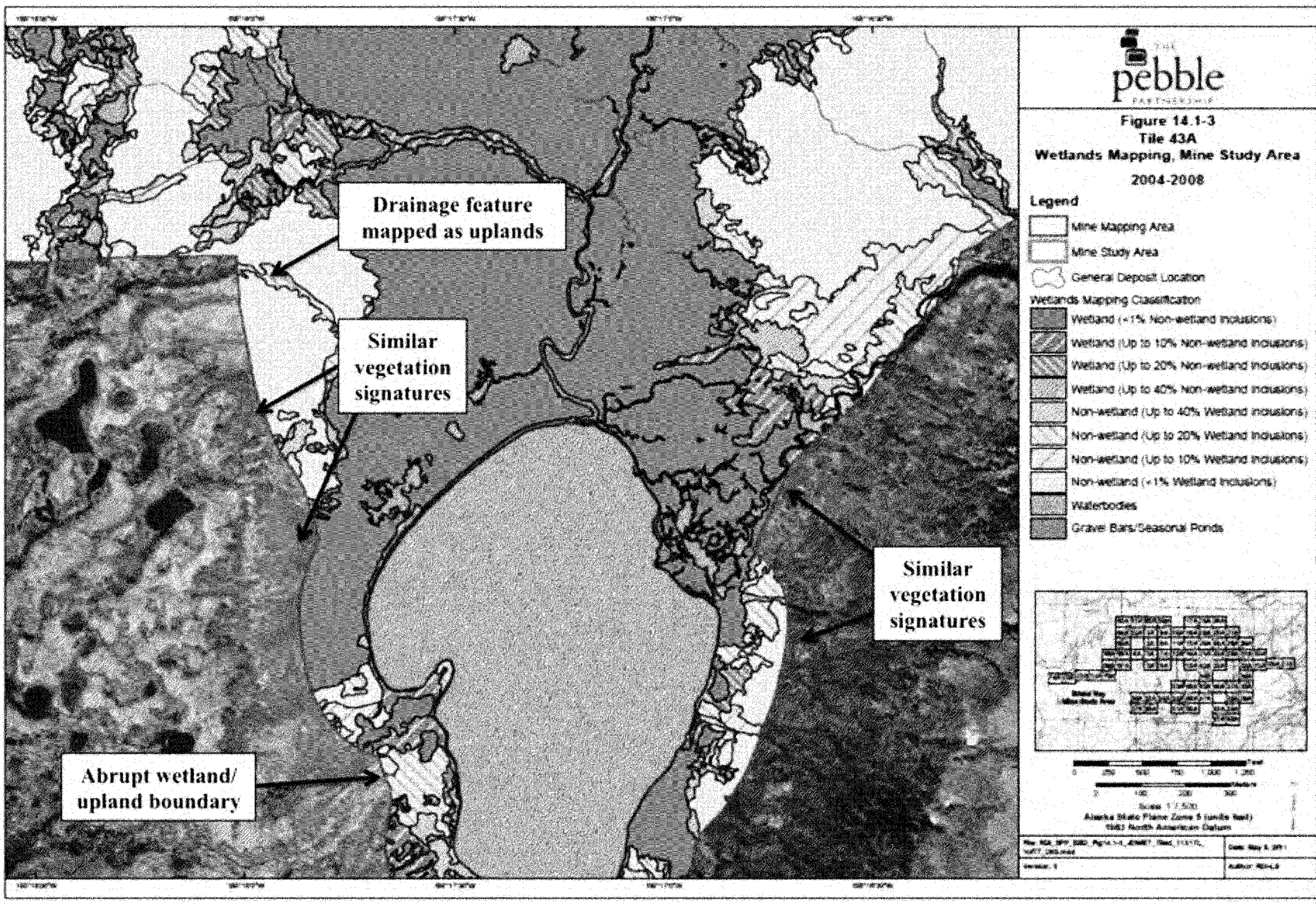


Figure 7. Examples of PLP wetlands mapping where similar vegetation and drainage patterns are mapped as wetlands in some instances and uplands in others.